THE DISTRIBUTION OF LOESS FOSSILS

IT has perhaps been noted that the loess molluscs thus far reported in the literature of the subject are, for the most part, from localities in close proximity to the larger streams. This fact may have suggested the thought to those unfamiliar with the modern habits and present distribution of these molluscs that the adjacent streams had in some way something to do with the entombing of the shells now found in the loess. That the loess is most richly fossiliferous near streams is generally, though not always, true. The abundance of fossils is a decidedly variable quantity. There are exposures near streams which exhibit fossils in profusion, and others which are wholly barren. On the other hand, exposures quite remote from streams contain fossils —though in such situations a proportionately much larger part of the loess is entirely devoid of them.

This fact has sometimes led geologists to attempt to distinguish, in varying degrees, between the loess adjacent to streams and loess more remote. Whatsoever distinction may be observed in the physical characters of the loess of various deposits,[1] no distinction can be based on the presence or absence of fossils alone. The simple fact that one deposit is fossiliferous and another is not, does not prove, nor even indicate, that the deposits were formed under wholly, or even materially different circumstances. In the one case there are no fossils simply because there were no shells to be buried; in the other, fossils are common because shells were abundant on the old land surfaces, where they were covered as other imperishable objects would have been covered.

Fossils are more abundant in the vicinity of streams because

[1] For one of the most recent discussions of the loess with reference to its variation according to distance from streams, see Dr. Chamberlin's article in the JOUR. GEOL., Vol. V, No. 8, p. 795.

the same species thrive, and in all probability did thrive in the past, in just such situations.

Manifestly, if we would judge of the conditions under which the fossils existed and were finally buried in the past, we must understand the conditions under which the same species exist today. It has already been pointed out by the writer[1] that the loess fauna of any section of the country closely resembles the modern molluscan fauna of the same section, the characteristic fossil species being for the most part characteristic species of the modern fauna. During the past summer the writer made more extended studies of fossils in widely separated loess regions, notably in Mississippi, Iowa (both eastern and western), and Nebraska, which strongly emphasize the foregoing fact. As questions of general geographical, as well as local, distribution of fossil and modern molluscs are of great importance in connection with any attempt at an explanation of the manner in which loess was deposited, the following remarks are offered as preliminary to further detailed reports upon the distribution of the loess species and of their modern representatives.

In Iowa and Nebraska, as elsewhere, the land shells form the characteristic fauna of the loess, and with two or three exceptions the same species may be found living within the borders of our state today.

The student who goes to the field to study the living forms in their natural environment, if his studies be sufficiently extended, will be struck by the many seeming eccentricities in distribution. He will, however, observe that our land molluscs as a rule favor the regions adjacent to streams — especially the rough, rugged hills which so often border them. This fact, however, seems to be dependent upon another, equally interesting and long well known — namely, that our timber areas for the most part skirt the streams — and that this distribution of vegetation determines largely the distribution of the molluscs is shown by the fact that the timber or brush-covered areas remote from streams are quite likely to yield plenty of shells. A few

[1] Proc. Iowa Acad. of Sciences, Vol. V, pp. 33, 41.

species (as for example *Succinea grosvenorii*) seem to favor open, rather grassy places, and a few others may be found among the weeds and bushes skirting prairie ponds, but as a rule rough, rolling timber areas are favored. Here an abundance of food (for nearly all are herbiverous) and more or less shade and protection are furnished by the vegetation. As we recede from the timber-bordered streams the number of species and specimens grows less, and the writer knows from personal experience obtained in various parts of the state that large prairie areas of that character may be searched in vain for any trace of a land mollusc. In the eastern part of the state, with its more rolling, timber-covered surface, almost every locality — certainly every county — presents numerous favorable locations for colonies of snails, but as the collector crosses the state westward he finds that in species and in specimens the molluscan fauna grows poorer, the timber-fringed streams or ponds and lakes alone marking the favorable localities.

If careful observations are made even in the best of these collecting grounds, whether in the eastern or western parts of the state, it will be found that much variation and inequality in local distribution exist. One hillside may present certain species, while the next, perhaps across a narrow ravine, will show a wholly different series, and a third near by may have none at all. A species which in one spot is the prevailing type, may, only a few rods or even feet away, be wholly or in part supplanted by another. This is sometimes due to differences in the abundance of trees and vegetation furnishing food, and to other variations in the character of the surface, but often it seems to be a mere accident.

The number of individuals of any, or all, species in a given locality is also very variable. In the most favorable spots, however, especially on higher grounds, one seldom finds many individuals together. Even such species as *Zonitoides arboreus*, *Z. minusculus*, *Vitrea hammonis*, *Cochlicopa lubrica*, *Succinea obliqua*, *S. avara*, etc., which may often be found in large numbers under leaves or sticks and logs in comparatively low places, usually show

fewer and more scattered specimens on hillsides, etc., especially in more open places. To get a good set of any species in such localities the collector must work over a considerable area, but in doing so he will almost invariably find individuals of several species mingled promiscuously. If he compares the molluscan faunas of the eastern and western parts of the state, he will find that, as stated, the number of species and individuals in the eastern part is, as a rule, greater. He will also find that there are certain rather striking differences between sets of some of the species taken at opposite extremities of the state. Those from the eastern part are likely to average larger in size and to be thinner shelled, resembling more nearly representatives from the eastern part of the country, while the western forms are smaller and heavier. This is especially true of *Polygyra mutilineata*, *Zonitoides minusculus*, *Succinea obliqua*, *S. avara*, and other species of the kind which are sometimes found in rather low places, but which also occur on higher grounds—especially westward. This is probably due chiefly to the scarcity of forests in the western and central parts of the state, where the rather scant groves usually consist of scattered and stunted trees, being quite different from the more vigorous forests of the eastern part. That this view is correct is further attested by the fact that the same species of molluscs, when occurring on comparatively barren or nearly treeless areas in the eastern part of the state, usually show the characters of the western types, namely, the smaller size and sometimes heavier, or at least more compact shell.

If the student will study the molluscs of a given region for a number of years, he will find that from year to year the abundance of the several species varies, some even running out entirely, while others unexpectedly appear. The writer has watched a number of localities near Iowa City for many years, and has found this variation often striking.

If, now, the distribution of the fossils in our loess is compared with that of the modern shells, a remarkable similarity is evident. The best collecting grounds are near streams, while the clay of the remote prairie is usually barren. Where fossils

are abundant one exposure contains species of one kind, another near by presents a new, or at least a different list, while still another has none—and the same variation which may be observed in the local distribution of the recent shells in any restricted locality, will be exhibited in individual exposures of fossiliferous loess.

In horizontal distribution the fossils show the same mode of distribution as that already noted in the modern forms. The specimens are not heaped together, but are scattered about like the modern shells, usually a number of species mingled together, but in unmodified loess invariably *not* crowded, so far as the writer's observations have gone.

The vertical distribution of the fossils also conforms to the surface distribution of the modern shells. If the loess was not deposited *in toto* at once, and this seems to be conceded, there were successive land surfaces upon portions of which shells grew. These shells varied from time to time in number, some persisted during long periods, some disappeared and others took their places. If we study the vertical distribution of the fossils in the loess the same variation in the succession of species is observed. Some species occur throughout the thickness of a particular exposure, but more frequently a part of the loess is without fossils, certain species occupy a part of the deposit, while above or below them are other species—as though the varying generations of surface species had been successively buried in the deposit. The number of specimens upon any one of the successive land surfaces was not very great even in richly fossiliferous loess, for if we draw lines approximately parallel to the present surface to represent the successive surfaces, we will find that in any one of them but few fossils occur.

Where depauperation or variation in size is noticeable in the fossils, it will be found that it takes place in the direction of the western modern forms. For example, while the common modern *Polygyra multilineata* at Iowa City is large, the common fossil form is small, though the small modern and the large fossil forms are also occasionally found, but not respectively with the

preceding forms. On the other hand, at Council Bluffs and Omaha the modern shells of this species are usually small, like those of the loess, though both fossil and modern shells of the large type occasionally occur. Thus the fossils of this species from the eastern part of the state resemble both the fossil and modern shells from the western part. *Succinea avara* is another example. The small typical form is common in the loess at Iowa City, but the modern shells are not frequent, occurring always on more or less wooded hillsides, while westward the type is the common modern form.

In the loess of both the east and the west,[1] *Sphyradium edentulum alticola*, *Pyramidula strigosa iowensis*,[2] *Succinea grosvenorii*, forms belonging now to the dry western plains, are quite common. Their presence, together with that of the "depauperate" forms, when considered in connection with the entire molluscan faunas of the eastern and western parts of the state, suggests a climate considerably drier than that of the eastern part of the state, and a surface less abundantly timbered. Certainly both modern and fossil faunas unmistakably show[3] that the conditions in the eastern and western parts of Iowa during the deposition of the loess were approximately included within the bounds of the present extremes presented by these regions, and that any attempt to drag into the discussion of this subject conditions either of a glacial climate or of frequent and widespread floods and inundations, or of any excess of moisture, is gratuitous.

The conditions which cause the depauperation of our shells exist more or less all over Iowa today, especially westward, and yet we do not have a glacial climate. If the molluscs

[1] The loess herein designated as "eastern" is that of eastern Iowa — the "western" being that of western Iowa and eastern Nebraska.

[2] This form has heretofore been reported as var. *cooperi* which lives abundantly in the far West, but Pilsbry regarded it as extinct and distinct, and has described it under the name *iowensis*. All living forms of *strigosa* belong to the high, dry regions of the West. Neither of these species was found at Council Bluffs, but both are found in the loess of Nebraska. *Sphyradium* was formerly included in *Pupa*.

[3] See also the writer's paper in Proc. Ia. Acad. Sci., Vol. V.— particularly p. 42.

of the loess be used as an absolute measure of the amount of moisture occurring during loess times, then we must conclude that Iowa was without streams, for practically no fluviatile molluscs occur in the loess, and that there were but few ponds in which aquatic molluscs found a favorable habitat, for even aquatic Pulmonates are rare in the loess,[1] the number of terrestrial forms being out of all proportion to that of the aquatic forms.

During the past summer the writer collected several thousand specimens in the loess of Mississippi and western Iowa, and among them all there were not a half dozen aquatic shells. A list of the modern shells of Iowa shows a large number of aquatic species, yet few of these occur in the loess. There is also among the modern terrestrial forms a large number of those which occur only in very damp places—and these, too, are almost wholly missing from the loess. The writer is well aware that many of the forms found in the loess are often referred to as aquatic or "semi-aquatic," or at least as favoring very wet situations. But evidence of this character has been furnished largely by those who are familiar only with the molluscan fauna of the eastern part of the country, where the amount of rainfall is much greater, and where surface conditions are not the same as in Iowa and Nebraska—or it has come from so-called "closet-naturalists." Now, the "closet-naturalist" has done abundant harm in this as in other branches of science. Too remote, often, from the phenomena under discussion, or too dainty to soil his fingers with the toil and the exposure of field-work, he has passed judgment upon the habits of forms which he knew only from material submitted by mail—or still worse, he has taken the work of others and, not appreciating the significance of the facts so borrowed, has distorted them to do menial service in the encouragement of some pet notion.

In the particular case in hand no distinction has been made between the habits of the depauperate varieties and the larger

[1] For more detailed comparisons see writer's paper (*loc. cit.*, pp. 43 and 44), and the discussion preceding.

types of the same species, and too often the habits of one species have been confused with those of another of the same genus, or even family, a mistake most frequently made with the Succineas. Again, the versatility of certain species—their adaptability to varying conditions—has been overlooked. *Zonitoides minusculus*, *Bifidaria pentodon*, *B. contracta*, *Succineaavara*, *S. obliqua*, etc., frequently occur in low places and then often in great numbers—but they are also found scattered over comparatively dry hillsides at considerable altitudes—and some of these species in such places develop the depauperate type, that is they average smaller in size. To show the preponderance of strictly terrestrial forms in the loess, the writer calls attention to the fact that in the collections made last June at Natchez and Vicksburg, Miss., numbering over forty species and nearly five thousand specimens, there is not a single aquatic form. Furthermore, every species which was collected in the loess of that region has been found by the writer, living upon the high bluffs and hills in and near Natchez, or upon hillsides at considerable elevations in other parts of the south, notably in northern Alabama, Georgia, and Tennessee.[1] At Natchez the most common living species is *Succinea grosvenorii*, and this crept upon the bare surface of the loess clay which, at the time of the writer's visit, had been baked by the hot summer sun of the south during a period of drouth lasting more than six weeks. Moreover, several scores of specimens which had been carried about in the sun all day long in a box containing loess dust, and hence were subjected to extremely desiccating conditions, were found, after this experience, creeping about in their prison seemingly perfectly contented. Yet we are sometimes told that the Succineas are all "semi-aquatic," or that they must have an abundance of moisture. Another illustration, equally striking, is furnished by the writer's experiences and observations at Council

[1] It is also a significant fact that of all the living species found in the hills and bluffs of Natchez, only two, *Leucocheila fallax*, and *Polygyra texana*, were not found in the loess of that region. Only one specimen of the first and two of the second were collected. The former is not uncommon in the loess of the north, while the latter is not known from the loess, at least to the writer.

Bluffs during the past summer and autumn. It had been purposed to make a detailed comparative study of the fossil and modern molluscan faunas of that vicinity, but the work was somewhat interrupted by the severe September rainstorms and November blizzards. Nevertheless interesting and valuable data were obtained, and are here briefly presented.

More than four thousand fossils were collected, and their distribution was carefully noted in twenty exposures, beginning at the eastern extremity of 15th avenue in Council Bluffs, thence along the bluffs to the High School, a distance of about one mile, and in Fairmount Park, along its winding roads, for about half a mile eastward. The location of the several exposures is shown on the accompanying map. A list of the fossil species, together with the number of specimens collected in each exposure, is given in the appended table. If this table is studied it will be observed that of the thirty species collected not one is aquatic. For purposes of comparison the writer made collections of recent shells in seven distinct localities in practically the region containing the above-noted exposures. These localities are here discussed in detail, the letters designating them being also employed to mark them on the map.

a. A grassy, treeless hillside in Fairmount Park nearly opposite 11th avenue, and at an altitude of from 175 to 245 feet above the river valley.[1] Species 8, 11, and 29[2] were found living.

b. A grassy, treeless slope just above the exposure marked *N.* Altitude about 200 feet. Species 8, 10, 11, 15, and 29 were found.

c. Near the 10th avenue entrance to Fairmount Park, at an altitude of about 90 feet above the river plain, species 8, 10, 11, 21, 22, 27, and 30 were found. A few stunted and scattered bur oaks grow on the slope immediately above this point.

d. A brush-covered hill just above the exposure marked *E.*

[1] The altitudes were all determined by barometric measurements taken from the nearest north and south street on the river flat.

[2] The numbers refer to the species named in the table of fossils.

Altitude about 170 feet. A small collection containing species 11 and 30 was made.

e. A locality in the northwestern part of Fairmount Park on a northerly slope, somewhat grassy, but with shrubs and a few bur oaks, nearly opposite 8th avenue. Altitude 280 to 300 feet above the valley. Here were found species 3, 8, 11, 13, 18, 19, and 27, and also one specimen of *Bifidaria procera*, the only recent species found in the tract examined, which was not found in the loess. This locality is just over the brow, on the north or leeward side,[1] of one of the most exposed ridges in the area under consideration.

f. A part of the same slope immediately below *e*, and 50 to 100 feet lower. Here the forest is better developed and contains a number of species of trees. Species 8, 11, 18, 19, 22, 25, and 28 were found. The points *e* and *f* are on the same very steep slope, but *e* is much more exposed and drier, *f* being more protected by its forest covering and position. A comparison of the species from these points is therefore interesting. Species 3 and 13, while common at *e* were not found at *f*, the lower point. While 18 was common at *e*, only one specimen was found at *f*. No. 19 is also more common at *e* than at *f*. These facts are of interest when we seek to determine the extent to which shells are likely to be washed down even very steep slopes. Nos. 8 and 11 were about equally abundant, while Nos. 22, 25, and 28 were found only at *f*.

g. The banks and grassy slope near and above the exposure *M*. This yielded species 3, 13, 21, 24, and 27.

It will be observed that species 1, 2, 4, 5, 6, 7, 9, 12, 14, 15, 16, 17, 20, 23, and 26—or just one half the total number—are not contained in the collections of modern shells cited. The number of individuals of the surface species is also comparatively small. Of these numbers, 1, 16, and 23 are extinct in that section of the country, No. 1 occurring eastward, No. 16 westward, and No. 23 being entirely extinct.

[1] The prevailing winds during the seasons of the year when the snails are active, are from the southwest.

The modern fauna of the more or less exposed hills at Council Bluffs is much poorer in species and in specimens than the fossil fauna of the underlying loess, but every species thus far discovered in the loess of Council Bluffs occurs more or less abundantly (certainly as abundantly in some places as in any part of that loess) living along the Missouri River, especially on the western, more heavily timbered bluffs. All the species above mentioned as not found in the surface collections have been collected, by the writer, on the banks and hills along the Missouri between Omaha, Neb., and Hamburg, Iowa, usually not in very damp places, but living under the conditions which prevail along those bluffs. Even *Polygyra multilineata* is there often found on high grounds, and then appears as a stunted form like that which is common in the loess.

The loess fauna of Council Bluffs is thus not only wholly terrestrial, but, with the exceptions noted, is almost identical with the modern upland fauna of the same region—and surely no conditions of excessive moisture prevail in that region today. Yet a recent writer,[1] referring to the loess of the Missouri region, says: "In the Bluff loess more than nine tenths of the total number of individuals belong to species that are found only in unusually damp situations. . . . . The species having an optimum habitat that is not excessively moist have not been observed to occur abundantly in the Bluff loess."

Another interesting fact noticeable in the exposures of loess at Council Bluffs is the occurrence of the great majority of the fossils in a more or less distinct stratum which varies (so far as observed) in altitude from about 80 to at least 200 feet above the river valley, and which follows in general the contours of the present surface, but with a less convex curvature. In exposure *N* it seems to be a continuation of the shell-bearing layer in *E*, yet it is at least 100 feet higher. In exposure *M* it drops about 80 feet in a block. Its limits are not sharply defined above or below, and it varies in thickness from about 6 to at least 20 feet. Overlying it is a deposit of more or less

[1] C. R. KEYES, Am. Jour. of Science, Vol. VI, p. 304.

laminated loess clay, which is usually non-fossiliferous, and which varies from a few to more than 30 feet in thickness. When fossils occur in this upper stratum they are few in number and widely scattered.[1]

The presence of this shell-bearing stratum suggests that, for the period during which it formed the surface soil, and while it was slowly accumulating, the conditions in this particular locality were more favorable to the growth of land snails than now. There was probably more vegetation, and hence the surface was not so frequently storm-swept as at present. This does not necessarily signify that general climatic conditions were different, but that these particular banks or bluffs were more heavily timbered, with the Missouri River probably flowing at its base, its surface conditions being similar to those of many timbered hills and knolls between Omaha and Nebraska City west of the Missouri.

It is interesting to note that between Iowa and Nebraska the Missouri River now flows along the western side of its broad valley, and that the adjacent western bluffs are more heavily timbered and contain all the living species of molluscs herein recorded, with the exception of Nos. 1 and 16, while the more remote eastern bluffs are more barren and rugged. The shell-bearing band may simply represent the period during which the river in its shiftings occupied the eastern part of the valley.

The foregoing facts lend support to the æolian theory of the origin of the loess, as is shown by the following considerations.

1. The general manner of distribution of the modern and fossil molluscs is essentially the same, this fact indicating that they were not carried by waters, but were quietly buried in dust. Had they formed a part of river drift they would be more frequently heaped together, not scattered as we find them in the loess, and fluviatile shells would be more or less intermingled.

[1] At the base of the bluff, in exposure *K*, what seemed to be a second shell-bearing layer was observed about 75 feet below the main fossiliferous band. The section, however, was more or less obscured, and the mass may have slipped from the bluff above. The fossils in column *K* in the table are from this stratum. It will be observed that they are ordinary forms which are abundant in the main shell stratum.

Moreover in many years' experience in dredging in ponds and streams, the writer has seldom seen a land shell which had been carried with the finest sediment into ponds or lakes, though such shells are sometimes found in sand and other coarse material. Currents of water which could carry most of the shells now found fossil, would also carry coarser material than that which makes up the loess. Another fact which bears out this conclusion is the presence of opercula in fossil shells of *Helicina occulta* in the northern loess and *Helicina orbiculta* in the southern loess. As the operculum so readily falls from the decaying animal, it would scarcely remain in place if the shell had been transported any distance.

2. The occurrence of fossiliferous loess chiefly in the vicinity of streams is consistent with the theory of loess formation presented by the writer before the Iowa Academy of Science.[1] Plants, and especially forests, develop chiefly and primarily along streams. This creates conditions favorable to land molluscs, and at the same time forms a trap for the dust carried from adjacent more barren regions. The occurrence of loess in the eastern part of Iowa chiefly along the border of the Iowan drift sheet may also be explained on the same ground. After the melting of the ice the terminal moraines offered the first lodging place for plants. Here forests early developed, and the conditions for entrapping the dust from adjacent less favored territory which was probably dry during a part of the year were here first created. We are in the habit of describing the lobed ridges of loess regions as characteristic of loess topography, yet they are quite as much characteristic of some drift areas, as for example, along the Big Sioux River in Iowa and South Dakota. In eastern Iowa the surface of the loess is largely shaped by the underlying moraines which first presented conditions suitable to the deposition of the loess, and where consequently the deposit is best developed. The loess at Natchez does not show this loess topography in the same degree.

3. The depauperation of some forms of shells, and the pres-

[1] Proc. Iowa Acad. Sci., Vol. III, p. 82 *et seq.*

ence of others which are normally inhabitants of dry regions, suggest a climate sufficiently dry that during a part of the year at least, clouds of dust could be taken up by the winds.

4. The overwhelming preponderance of land snails in the loess must always be borne in mind. This however does not prove that the loess regions were entirely devoid of lakes and streams, but rather that the loess proper was deposited chiefly upon higher grounds, for, if by any agency fine material were to be uniformly deposited over all of Iowa today, covering the successive generations of our present molluscan fauna, there would be a much greater proportion of aquatic and moisture-loving species than we find anywhere in the loess.

5. The amount of material carried by the winds need not have been so great as is sometimes assumed. The estimate made by the writer[1] for the rate of deposition for eastern loess (1 mm per year), and that made by Keyes[2] for western loess ($\frac{1}{10}$ to $\frac{1}{4}$ of an inch), would be sufficient to form most of these deposits respectively in the 8000 years, usually computed, since the recession of the glaciers.

The objection made by Dr. Chamberlin[3] that "the æolian deposits are measured, not by the quantity of silt borne by the winds and lodged on the surface, but by the difference between such lodgment and the erosion of the surface," is met, at least in part, by the theory offered, for it is a well-known fact that timbered areas, even when very rough and with abrupt slopes, are scarcely eroded by even the most violent precipitation of moisture. Professor Udden's recent admirable report[4] also bears on this question, and should not be overlooked by the student of loess problems.

6. No distinction can be made between the origin of eastern and western loess. The finer quality and lesser thickness of the former rather suggest that there had been more moisture (*i. e.*,

[1] Proc. Iowa Acad. Sci., Vol. III, p. 88.

[2] Am. Jour. of Sci., Vol. VI, pp. 301, 302.

[3] JOUR. GEOL., Vol. V, p. 801.

[4] The Mechanical Composition of Wind Deposits, 1898.

a shorter dry period during each year), and hence less dust; that the winds were less violent, and that there were greater areas completely covered with vegetation, this resulting in the necessity of transporting dust much greater distances, which would therefore be finer.[1]

It should be borne in mind that the above-noted differences between the regions in question actually exist today. There is more rain, there are larger areas closely covered with vegetation, and less violent winds prevail, in eastern Iowa, and eastward, and considering the position of mountain chains and seas, the same differences must have existed for a long time. That they did exist during the deposition of the loess is also indicated by the proportionately somewhat larger number of species in the eastern loess, which prefer or require moist habitats. But the fauna of the eastern, or Mississippi River loess is essentially a terrestrial fauna. The great fluviatile groups now everywhere common in the streams of eastern Iowa are wanting in the loess, and the few fossil aquatic species are such as today prefer ponds, and are often found even in those which dry up during the summer.

It may again be emphasized that the fossils show no greater difference between the surface conditions which existed during the deposition of the loess of the eastern and the western parts of Iowa, than exists today between the surface conditions of the same regions. This fact is irrefutable, and must not be overlooked in any discussion of the conditions under which loess was deposited.

NOTES AND EXPLANATION OF MAP

[Scale, 8 in. to 1 mile]

The exposures are represented by heavy lines.

EXPOSURES *A*, *B*, and *C*

These were cut out of the same ridge in street grading. The shell-bearing stratum shows well on the east, south and west sides of *C*. It is about 12–15 feet thick. Above it there is a layer of clay about fifty feet thick and almost entirely devoid of fossils.

[1] See UDDEN, *loc. cit.*, pp. 56, 57 and 67.

TABLE OF SPECIES[1]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1. *Helicina occulta* Say	5	55	210	5	5	81	17	89	9	14	3	12	14	96						
2. *Vallonia gracilicosta* Reinh.	10	157	12		1	8		21		3	1	1	1	45	1			1		
3. " *parvula* Sterki	2																		1	
4. " *perspectiva* Sterki	3	12																		
5. *Polygyra multilineata* (Say) Pils.		6	70	2		16	4	7		6	1		2	3	1		2		1	1
6. " *profunda*[2] (Say) Pils																				
7. " *hirsuta*[3] (Say) Pils.	1																			
8. " *leai* (Ward) Pils.	4	21	63	1	1	17	2	14		4			1	12			2			
9. *Strobilops virgo* Pils.	8		3			2		1	1					1						
10. *Leucocheila fallax* (Say) Try.		2																		
11. *Bifidaria armifera* (Say) St.	35	280						3	1											
12. " *contracta* (Say) St.	5																			
13. " *holzingeri* (St.) St.								1												
14. " *curvidens* (Gld.) St.	1																			
15. " *pentodon* (Say) St.												2	4	12			2	3	2	
16. *Pupa blandi* (Morse) Binn	11	127			1															
17. *Vertigo bollesiana* Morse												10	3	28						
18. *Cochlicopa lubrica* (Müll.) P. & J.	1	4	27	1	1	12		22	1	2				18						
19. *Vitrea hammonis* (Ström.) P. & J.	2	3	10			10	1	3			1	1		1						
20. " *indentata* (Say) P. & J.			1																	
21. *Conulus fulvus* (Drap.) Müll.						1		1	1				1	5						
22. *Zonitoides arboreus* (Say) St.	3	4	21			4	2	12						10			3			
23. " *shimekii*[4] (Pils.) P. & J.															2		1		2	
24. " *minusculus* (Binn.) P. & J.	1	2	6			1		3			1			7						
25. *Pyramidula alternata* (Say) Pils.		4	19		1	4	1	11	3	2				1						
26. " *striatella* (Anth.) Pils.	1	20	46	3		21		28	2		1	4	4	24	2			3	1	
27. *Helicodiscus lineatus* (Say) Morse	6	18	6		1	7		5						13						1
28. *Succinea obliqua*[5] Say }	3	180	935	8	10	235	58	279	8	72	21	12	5	250	4	2	15	3	15	3
29. " *grosvenorii* Lea }																				
30. " *avara* Say	15	11	16			7	1	11		2	1	3	2	14	4	2		3	5	
31. Egg of a land snail						1										1				

EXPOSURE *D*

The shell stratum is not so rich in fossils as in *C*. Above it there are 15–20 feet of clay in which a few Succineas were found. In the clay below the shell stratum there are several distinct but irregular bands of lime nodules—some very large.

EXPOSURE *E*

Very similar to *D*, but with only one band of nodules.

EXPOSURE *F*

Fossils are very abundant in the shell stratum, which can here be traced for 3 or 4 rods. The shell-less loess above is 8 or 10 feet thick.

EXPOSURES *G*, *H*, *I*, *J*, and *K*

These exposures were all formed from the same ridge by deep cutting and grading. The shell stratum is distinct in all of them, and, as in all the other sections, it follows in general the contour of the surface. It varies in thickness here from 6 to 20 feet. It is by no means equally fossiliferous throughout.

EXPOSURES *L* and *M*

These were formed by the grading of High School avenue. The street slopes westward from the High School, and drops about 60 feet in a block.

[1] The nomenclature of Pilsbry and Johnson's recent *Catalogue of the Land Shells of North America* is here employed. As there are some departures from former usage, the changes are here noted:

Species 2, 3, and 4 were formerly included under *V. pulchello*.

Species 5 and 6 were referred to the genus *Mesodon*, and 7 and 8 to *Slenotrema*.

Species 9 was included under *Strobila labyrinthica*.

The species of *Leuchochila* and *Bifidaria* were included in *Pupa*.

Species 18 was called *Ferussacia subcylindrica*.

Vitrea, *Comulus*, and *Zonitoides* were formerly placed in the genus *Zonites*, and No. 19 was called *Zonites radiatulus*.

Pyramidula was formerly *Patula*.

Species 29 was called *S. lineata*.

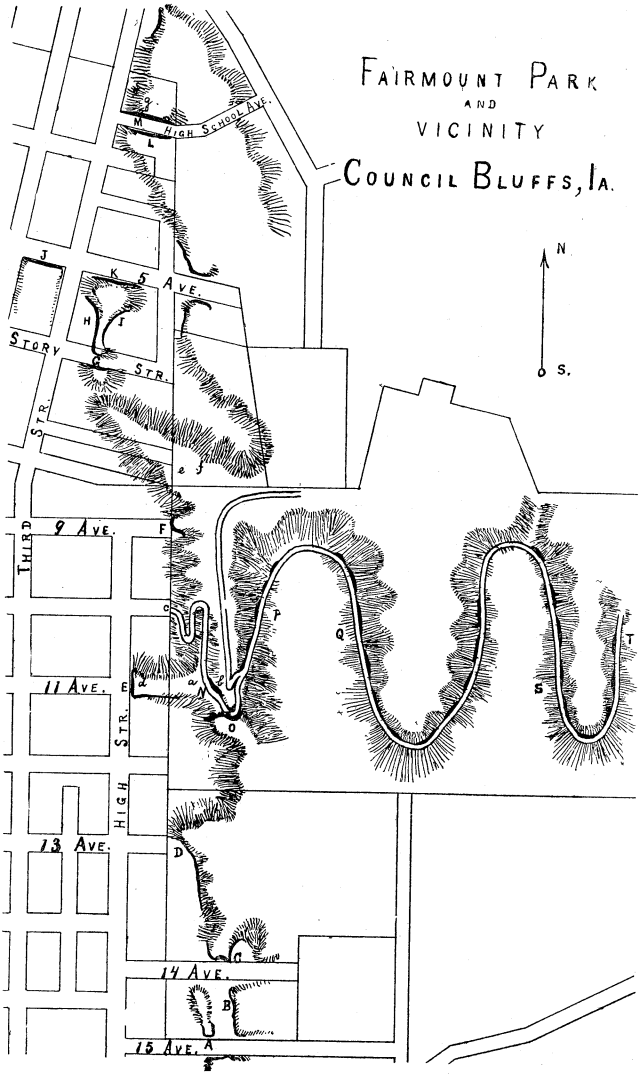
[2] One specimen of *P. profunda* was found by the writer in exposure C (since considerably altered) in 1890.

[3] Three specimens of this species were collected in exposure C in 1890.

[4] The writer formerly regarded this as a form of *Zon. nitidus*. Mr. Pilsbry, however, regards it as distinct, and in deference to his opinion his name is retained.

[5] The form of *S. obliqua* which occurs most commonly in the loess is the narrower, smaller form, with more extended spire, such as is not uncommon (living) in Iowa and as far east as Indiana. As it is difficult to distinguish between some forms of this and *S. grosvenorii*, the two species are not here separated, as more time for careful comparison of the large sets will be required.

On the north side the shell stratum is nearly parallel to the street grade, and but little above it. On the south side it dips below the street about half way down the slope.



EXPOSURES *N*, *O*, *P*, *Q*, *R*, *S*, and *T*

These are all exposures along the road which winds eastward from the 10th avenue entrance to Fairmount Park. At *N* the road is about 185

feet above the river valley, and the shell stratum (which is here very rich in fossils) extends about 3 feet higher. It dips down toward the west at such an angle that it would connect with the shell stratum at *E*, which is about 100 feet lower. The same layer may be traced more or less indistinctly to *O*, where there is a cut about 20 feet deep. The shell stratum rises to about 8 feet above the roadbed (here about 200 feet above the river valley), but fossils are not abundant. The remaining exposures along this road are formed by the road cutting the smaller, lateral lobes of the greater ridges. The letters apply to the extent of road from bend to bend, not to individual exposures. At the southern bends in the road are the high points, the road sloping down to near the bases of the ridges to the north.

Fossils are found in most of the little exposures (which in but few cases exceed 15 feet in height) along the road, but they are nowhere as abundant as in some of the exposures along the bluff fronts. The exposures which are represented on the map, but not lettered, are nonfossiliferous.

B. SHIMEK.